Triple faced oxide: Electric-field controlled dual-ion switch

With financial support from the National Natural Science Foundation of China, a research team led by Associate Professor Yu Pu (于浦) at the Department of Physics in Tsinghua University published their seminal work recently in the prestigious journal *Nature* (2017, 546: 124－128). The work, titled "Electric-field control of tri-state phase transformation with a selective dual-ion switch", reports for the first time the reversible and nonvolatile electric-field control of phase transformations among three distinct crystalline phases through the selective dual-ion (oxygen and hydrogen) switch in the same materials, and the discovery further reveals conceptually new tri-state electrochromic and magnetoelectric effects.

Electric-field control of phase transformation with ion transfer is of great interest in materials and physics science with enormous and important practical applications, such as batteries, smart windows, and spintronic devices. Increasing the number of transferrable ion species and of accessible crystalline phases could in principle greatly enrich material functionality. However, studies have so far mainly focused on the evolution and control of single ionic species (for example, oxygen, hydrogen or lithium ions) or through high-temperature thermal annealing, while electric-field control of phase transformation based on selective dual-ion has not yet been reported. Through the creative design, Prof. Yu and his team realized the electric-field control of dual-ion (oxygen and hydrogen) tri-state phases transformation among the model system of brownmillerite $SrCoO_{2.5}$ and its counterpart of perovskite $SrCoO_{3-\delta}$ and a hitherto-unexplored $HSrCoO_{2.5}$ phase by employing the ionic liquid gating. Because of the extremely distinct optical, electrical and magnetism properties among these three phases, this result can be readily applied to applications of electrochromic, resistive switch, magnetoelectric coupling devices, etc.

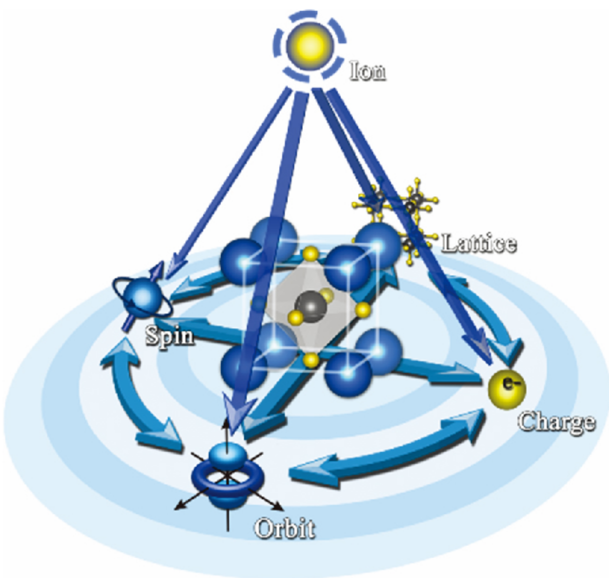

Figure Ionic evolution: a novel strategy to "redesign" quantum material.

The correlation and competition between charge, spin, orbital and lattice degrees of freedom forms the essential foundation in condensed matter physics and material science and leads to a rich spectrum of novel magnetic and electronic states. While this work represents a substantial advance in the filed, suggesting a novel strategy to design novel functionalities through the coupling between the electric field controlled ionic evolution with all of these freedoms. This approach can be readily extended to a large variety of the material system and opens up exciting possibilities for future discovery.